Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 03 (MAY-JUNE, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Phytodrugs in Aquaculture: A Sustainable Alternative to Antibiotics

*Ayush Chandravanshi and Astha Deshmukh
Department of Fisheries, Chhattisgarh, India
*Corresponding Author's email: ayushchand1998@gmail.com

Aquaculture is one of the fastest-growing food production sectors globally and plays a crucial role in ensuring food security and nutritional sustainability. However, intensification of aquaculture practices has increased the incidence of infectious diseases caused by bacteria, viruses, fungi, and parasites. To control these diseases, antibiotics have been widely used for treatment and prevention. Excessive and indiscriminate use of antibiotics has led to the emergence of antimicrobial resistance (AMR), accumulation of drug residues in fish products, environmental contamination, and disruption of aquatic microbial communities (Newaj-Fyzul et al., 2022; Dawood et al., 2018). Consequently, there is an urgent need for eco-friendly and sustainable alternatives to conventional antibiotics. Phytodrugs, also known as phytotherapeutics or plant-derived medicines, have emerged as promising candidates for improving fish health and disease resistance while reducing reliance on synthetic chemicals.

What are Phytodrugs?

Phytodrugs are bioactive compounds derived from medicinal plants, herbs, spices, and plant extracts that possess antimicrobial, immunostimulatory, antioxidant, antiparasitic, and growth-promoting properties. These compounds include alkaloids, flavonoids, phenolics, terpenoids, tannins, saponins, and essential oils. Unlike conventional antibiotics, phytodrugs are biodegradable, environmentally friendly, and generally considered safer for both aquatic animals and consumers (Reverter et al., 2014; Sharma et al., 2026).

Need for Alternatives to Antibiotics in Aquaculture

The widespread use of antibiotics in aquaculture has contributed significantly to the development of resistant bacterial strains. Antibiotic-resistant pathogens not only threaten aquaculture productivity but also pose risks to human health through the food chain and aquatic environment. Furthermore, antibiotic residues in fish products may lead to trade restrictions and consumer concerns regarding food safety. Sustainable disease management strategies are therefore essential for maintaining productivity while minimizing environmental and public health risks (Dawood et al., 2018; Newaj-Fyzul et al., 2022).

Mechanisms of Action of Phytodrugs

Phytodrugs improve fish health through multiple mechanisms. Many plant extracts exhibit direct antimicrobial activity against fish pathogens by disrupting microbial cell membranes and inhibiting essential metabolic pathways. Certain phytochemicals enhance innate and adaptive immune responses by stimulating phagocytic activity, lysozyme production, respiratory burst activity, and cytokine expression. Additionally, antioxidant compounds present in medicinal plants reduce oxidative stress and improve physiological performance in fish (Reverter et al., 2014; Harikrishnan et al., 2011). Another important advantage of phytodrugs is their ability to act as growth promoters. By improving feed utilization, digestive enzyme activity, and gut health, phytogenic additives can enhance growth

performance and feed conversion efficiency. These combined effects contribute to improved disease resistance and overall fish welfare.

Common Phytodrugs Used in Aquaculture

Several medicinal plants have demonstrated beneficial effects in aquaculture:

- **Garlic (Allium sativum):** Garlic contains allicin, a potent antimicrobial compound effective against bacterial and parasitic infections. It also enhances immune responses and growth performance in fish (Nya and Austin, 2009).
- **Turmeric (Curcuma longa):** Curcumin, the principal active compound of turmeric, possesses strong antioxidant, anti-inflammatory, and antimicrobial properties. Dietary turmeric supplementation has been shown to improve immunity and disease resistance in cultured fish (Sahu et al., 2008).
- **Neem (Azadirachta indica):** Neem extracts exhibit antibacterial, antifungal, antiviral, and antiparasitic activities. Neem-based formulations are commonly used to control external parasites and improve water quality.
- **Aloe vera:** Aloe vera contains polysaccharides and bioactive compounds that stimulate immune functions and promote wound healing in fish.
- **Holy Basil (Ocimum sanctum):** Tulsi possesses immunomodulatory and antimicrobial properties and has been reported to enhance survival rates following pathogen challenge.
- **Ginger (Zingiber officinale):** Ginger supplementation improves digestive efficiency, growth performance, antioxidant status, and resistance against bacterial infections.

Applications of Phytodrugs in Fish Health Management

Phytodrugs can be administered through feed additives, immersion baths, or direct application in culture systems. Among these methods, dietary supplementation is the most practical and widely adopted. Herbal feed additives have been successfully used to enhance immunity and reduce disease outbreaks in species such as common carp, tilapia, catfish, rainbow trout, and shrimp. Research has demonstrated that phytogenic compounds can effectively control important fish pathogens such as *Aeromonas hydrophila*, *Vibrio* spp., *Edwardsiella tarda*, and *Streptococcus* spp. In addition, plant-derived compounds have shown efficacy against fungal and parasitic infections, making them versatile tools in integrated fish health management (Newaj-Fyzul et al., 2022).

Challenges and Future Prospects

Despite their promising potential, several challenges limit the large-scale adoption of phytodrugs in aquaculture. Variability in plant composition due to geographical location, cultivation conditions, and extraction methods can affect efficacy. Standardization of formulations, determination of optimal dosages, safety evaluations, and regulatory approval remain important areas requiring further research (Sharma et al., 2026). Advances in phytochemistry, nanotechnology, and feed formulation are expected to improve the stability, bioavailability, and effectiveness of plant-derived compounds. Future studies focusing on molecular mechanisms, large-scale field trials, and commercial product development will facilitate the wider application of phytodrugs in sustainable aquaculture.

Conclusion

Phytodrugs represent a promising and environmentally sustainable alternative to antibiotics in aquaculture. Their antimicrobial, immunostimulatory, antioxidant, and growth-promoting properties make them valuable tools for improving fish health and reducing the dependence on synthetic chemotherapeutics. Although challenges related to standardization and commercialization remain, increasing scientific evidence supports the integration of phytotherapy into modern aquaculture practices. The adoption of phytodrugs can contribute significantly to sustainable fish production, improved animal welfare, and mitigation of antimicrobial resistance, thereby supporting the long-term growth of the aquaculture industry.

References

1. Dawood, M.A.O., Koshio, S., & Esteban, M.Á. (2018). Beneficial roles of feed additives as immunostimulants in aquaculture. *Reviews in Aquaculture*, 10, 950–974.
2. Harikrishnan, R., Balasundaram, C., & Heo, M.S. (2011). Impact of plant products on innate and adaptive immune systems of cultured finfish and shellfish. *Aquaculture*, 317, 1–15.
3. Newaj-Fyzul, A., et al. (2022). Phytocompounds as an Alternative Antimicrobial Approach in Aquaculture. *Antibiotics*, 11, 427.
4. Reverter, M., Bontemps, N., Lecchini, D., Banaigs, B., & Sasal, P. (2014). Use of medicinal plants in aquaculture. *Aquaculture*, 433, 50–61.
5. Citarasu, T. (2010). Herbal biomedicines: A new opportunity for aquaculture industry. *Aquaculture International*, 18, 403–414.
6. Nya, E.J., & Austin, B. (2009). Use of garlic (*Allium sativum*) to control *Aeromonas hydrophila* infections in rainbow trout. *Journal of Fish Diseases*, 32, 963–970.
7. Sahu, S., Das, B.K., Mishra, B.K., Pradhan, J., & Sarangi, N. (2008). Effect of *Curcuma longa* on immunity and disease resistance in fish. *Fish & Shellfish Immunology*, 25, 461–466.
8. Chakraborty, S.B., & Hancz, C. (2011). Application of phytochemicals as growth promoters and health enhancers in aquaculture. *Reviews in Aquaculture*, 3, 103–119.
9. Van Hai, N. (2015). The use of medicinal plants as immunostimulants in aquaculture: A review. *Aquaculture*, 446, 88–96.
10. Pandey, S., Singh, G., Verma, S., et al. (2025). Phytotherapy as a natural alternative to antibiotics in aquaculture. *Indian Journal of Animal Health*, 64(1), 55–65.
11. Sharma, A., Iqbal, G., Quyoom, N., et al. (2026). Phytotherapy in aquaculture as a sustainable alternative to antibiotics for disease management. *Discover Animals*, 3, 48.
12. Hoseinifar, S.H., Sun, Y.Z., Wang, A., & Zhou, Z. (2018). Probiotics as sustainable alternatives to antibiotics in aquaculture. *Reviews in Aquaculture*, 10, 1–15.